Anopheles hermsi N. SP., An Unrecognized American Species of The *Anopheles maculipennis* Group (Diptera: Culicidae)[1]

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ABSTRACT. A new species, *Anopheles (Anopheles) hermsi*, is described based on eggs, larvae, pupae, and adult females and males. Previously unpublished keys of Belkin and McDonald are presented that will identify most larvae and pupae. The only certain means of identification is by examination of the chromosomes.

Lewallen (1957) described differences in the patterns produced by chromatographic analysis of adult *Anopheles occidentalis* from different locations in California; patterns from specimens from San Diego and Orange Counties differed from those from San Luis Obispo and Santa Cruz Counties. He also noted that specimens from southeren California lacked the pale fringe scales at the wing tip which are characteristic of specimens from farther north. Aitken (1945) and other authors had earlier noticed the lack of pale fringe scales on the wing tips in specimens taken from southern coastal areas of California. Aitken wrote, "In California *A. maculipennis occidentalis* extends from Ventura in a narrow strip along the coast almost to the Oregon border...at present it is known from about forty different localities along the coast." Specimens from the type series of *occidentalis* from San Diego, which had dark fringe scales on the wing tips, Aitken identified as *A. maculipennis freeborni*. He wrote that this form "reaches the coast in southern California, from San Luis Obispo southward."

Baker and Kitzmiller (1963) designated the southern form "southern *occidentalis*." They crossed it with *freeborni* and stated that the "southern *occidentalis*" population "has an unmistaken homology with *freeborni*, as shown by pairing of certain regions of the X-chromosome in heterozygotes." In a later paper (1965) these authors described the chromosomes of true *occidentalis* (type locality San Mateo County) but did not mention "southern *occidentalis*" at all.

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J. N. Belkin and W. A. McDonald in an unpublished manuscript presented keys for differentiating both larvae and pupae of "southern *occidentalis*" from other *maculipennis* complex forms that occur in California; the unpublished data of these workers deposited in the U. S. National Museum were made available through the courtesy of Michael Faran.

Anopheles hermsi N. Sp.

Female. Apparently indistinguishable from *An. freeborni;* lacks the pale fringe of scales at the wing tip characteristic of *An. occidentalis.*

Male. Apparently indistinguishable from *An. freeborni.* No differences have been found in the male genitalia.

Pupa. Similar to *An. freeborni* except as indicated.

Key to Pupae of *Anopheles* in California
(Belkin and McDonald, unpublished)

1. Seta 9-VIII usually long and single, sometimes branched at the tip ..... *franciscanus*

   Seta 9-VIII with branches all along the shaft 2

2. Remainder of number of branches of setae 1-II less those of 1,V,VI greater than 7 (M=15.05, SD=3.69)* ..... *punctipennis*

   Remainder of above combination 7 or less (M=0.46, SD=3.13) 3

3. Sum of number of branches of setae 2-III, 5-III and 2-VI greater than 32 (M=40.31, SD=6.13) ..... *freeborni*

   Sum of above combination 32 or less (M=26.50, SD=4.41) 4

4. Sum of branches of setae 2-VI, 1-V and 5-VII 14 or less (M=12.63, SD=1.86)..... *occidentalis*

   Sum of above combination greater than 14 (M=18.33, SD=2.75) ... . *hermsi*

In making the above computations the number of branches in the seta on each side of the body is counted and the total is used in the computation; if one of the pair is missing the number of branches in the remaining seta is doubled. Belkin and McDonald indicate that couplet 2 correctly identified about 97% of specimens, couplet 3 about 91% and couplet 4 about 89%.

*M=mean, SD=standard deviation

Larva. Similar to *An. freeborni* except as indicated.

Key to 4th-Instar *Anopheles* Larvae of California
(Belkin and McDonald, unpublished)

1. Inner anterior clypeals (seta 2-C) widely separated; 3-C unbranched ..... *franciscanus*

   Inner anterior clypeals close together; 3-C highly branched 2

2. Remainder of branches of setae 3-VII, VIII less sum of branches of 5-I and 2-II greater than 2 (M=8.56, SD=3.39) ..... *punctipennis*

   Remainder of above combination 2 or less (M=-5.43, SD=3.85).... 3

3. Sum of branches of setae 13-III, 2-IV, 2-V and 2-VI 28 or more (M=34.23, SD=5.03) ..... *freeborni*

   Sum of above less than 28 (M=21.05, SD=4.95) 4

4. Sum of above 22 or less (M=18.93, SD=3.04) ..... *occidentalis*

   Sum of above greater than 22 (M=27.55, SD=3.93)..... *hermsi*

Belkin and McDonald indicated that couplet 2 correctly identified about 97% of specimens, couplet 3 91%, and couplet 4 89%.

Egg. The eggs of *hermsi*, like those of *freeborni* and *occidentalis*, have fine punctations dorsally so that the egg grossly appears gray. The other American *maculipennis* group species, *aztecus* and *earlei*, have black and barred eggs, respectively. The following measurements are of eggs of laboratory colonies of *occidentalis* from Coyote Hills Regional Park, Alameda County, California, *freeborni* from Davis, Yolo County, California and *hermsi* from its type locality, Malibu Canyon, Los Angeles County, California.

Dimensions of eggs of the
California *An. maculipennis* group (in micrometers)

Species	Length	Width	Float length
hermsi	628±29	124±2	112±29
freeborni	640±37	146±16	179±30
occidentalis	612±13	145±10	145±13

The eggs of *hermsi* are significantly narrower and have shorter floats than do those of *freeborni* and *occidentalis* but there is much overlapping between the species and much variability in populations so egg morphology is not a reliable criterion for differention of *hermsi* from the other species that occur in California.

Holotype: female, California, Los Angeles County, Malibu Canyon at Pacific Coast Highway; VIII/10/87; S.E. Cope; 4th stage larval and pupal exuviae, labelled 1011A have been deposited in the U. S. National Museum collection. As was intended by Belkin, the species is named in honor of William B. Herms, who contributed so greatly to the study of medical entomology in California.

Fujioka (1986) found in crosses of the above colonies that when *occidentalis* was crossed with either *hermsi* or *freeborni* the F_1 males were almost invariably sterile; the only exception was one experiment in which 2% of eggs laid by *freeborni* females mated with hybrid males (*freeborni* female x *occidentalis* male) hatched. Hybrid females when backcrossed to males of either *freeborni* or *occidentalis* laid eggs of which 24 - 37% hatched. In crosses of *hermsi* and *freeborni* almost no fertile males were produced when *freeborni* males were employed. When *hermsi* males were employed the resulting F_1 males were backcrossed to females of *hermsi* or *freeborni* and 25-36% of the eggs hatched. The results demonstrate almost total genetic sterility between *occidentalis* and the other 2 species and a large amount of genetic sterility between *hermsi* and *freeborni*.

The chromosomes of the salivary glands of the 3 species were examined by Menchaca (1986) who found that the X-chromosome of *hermsi* had a characteristic terminal puff which was not found in either *occidentalis* or *freeborni*. This is the only reliable means for distinguishing individuals of the 3 species that we have found. Belkin and McDonald were able to distinguish populations based on larval and pupal morphology, but were not able to identify individuals. Morrison (1985) described the chromosomes of the ovarian nurse cells of *hermsi* and showed that the characteristic puff of that species could be used to distinguish it from *occidentalis* and *freeborni*. The presently known distribution of *hermsi* is southern California and probably Baja, California. Neither *freeborni* nor *occidentalis* has been found by us south of the Tehachapi Mountains although there are numerous older records of both species in the literature. We have not been able to confirm Aitken's record of *occidentalis* from Ventura County, but have confirmed its presence in Santa Barbara County. Several thousand specimens of *hermsi* have been deposited in the collection of the School of Public Health at UCLA. Belkin and McDonald's collections were deposited in the U. S. National Museum.

Anopheles hermsi apparently was responsible for epidemics of *vivax* malaria in San Diego County, California in 1986 (Turley et al. 1986) and 1988. The 1986 epidemic comprised 27 cases which were reported from June 18 to September 20 and occurred near Carlsbad, California. 25 of the cases were Mexican migrant agricultural workers, several of whom were from areas in Mexico where malaria is endemic; 2 were local residents. Surveys of the locale carried out in August, the time at which an epidemic was suspected, revealed abundant breeding of *hermsi*

and *franciscanus*. CO_2 collections consisted preponderantly of *hermsi* and biting collections revealed only *hermsi*. Unfortunately, control was carried out before a search was made for infected specimens. This year, 1988, a second epidemic occurred a few miles away near Del Bios, comprising more than 30 cases of which 2 were local residents. CO_2 traps that had been placed a few miles away indicated large and increasing populations of *hermsi* and few and decreasing numbers of *franciscanus*. Both epidemics largely involved agricultural workers who lived and slept in the fields in makeshift shelters. Present indications are that *hermsi* is an efficient vector of *Plasmodium vivax*.

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